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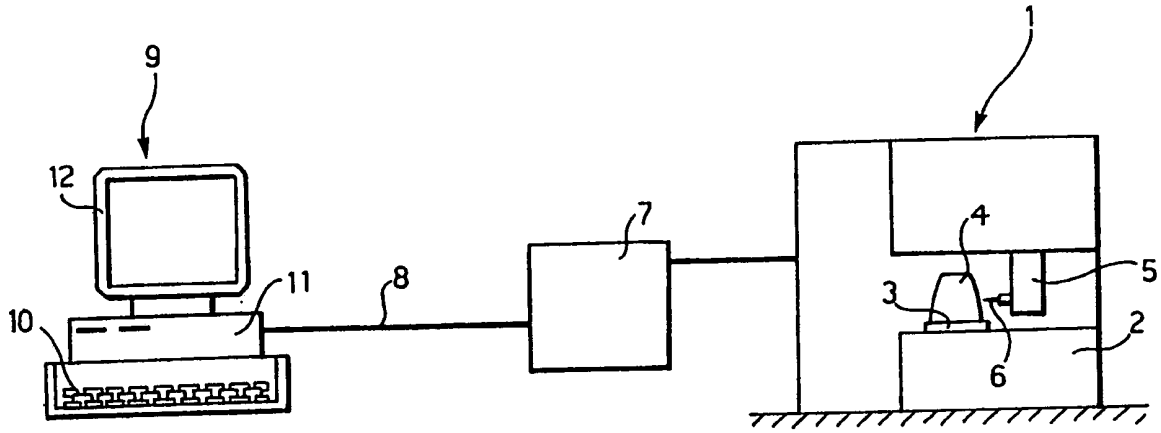
(54) Title: A REAL TIME TOOL WORKING SYSTEM, IN PARTICULAR A GRINDING SYSTEM



(57) Abstract

The system comprises a machine tool (1) with an associated computerised numerical control system (7) and a CAD work station (9) of interactive graphic type. This includes an electronic processing unit (11) arranged to determine, on the basis of a mathematical model of the shape to be formed and the nominal geometrical characteristics of the blank work piece (4), the coordinates of the points which define the paths intended to be followed by the tool (6) for working the blank work piece (4), and for transmitting to the numerical control system (7) of the machine (1) the coordinates of the points of the said paths, gradually as they are calculated, for their immediate execution by the machine (1).

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A real time tool working system, in particular a grinding system

The present invention relates to a tool working system, in particular a grinding system, for producing a workpiece such as a die for a motor vehicle body part, starting from a die blank of predetermined nominal shape and dimensions. In current known methods for the production of such a die, the design is first drawn up and, then, a mathematical model thereof is defined, for example by means of currently available modern CAD (Computer Aided Design) instruments.

The mathematical model, usually integrated with the shape of any possible ancillary surfaces (surfaces outside the drawing) is utilised for the subsequent generation of a part program and for definition of the track or path intended to be followed by the tool of the machine utilised. This path is defined in relation to the nominal dimensions of the die blank from which the desired shape is to be formed by working with the tool, the type of tool provided, the acceptable tolerance limits, the type of tool movements etc.

Once the programme relating to the tool path has been set us and checked this is transferred in the workshop to the numerical control system of the machine tool used. The

working can then be started.

In the above described traditional method it can happen that the preliminarily programmed path of the tool is not entirely adequate effectively to produce the desired shape. This may be for example because of the fact that the die blank used has dimensional characteristics which depart from the nominal characteristics taken into consideration in programming the path. This may mean for example that in order to produce the desired shape the machine must remove a greater amount of stock than that envisaged.

With the traditional method it is then necessary in this case to suspend working and proceed to re-programming of the working in such a way as to take into account the detected differences or errors or possibly other indications deriving from the operator's experience of the machine. Often the suspension of working also involves discarding the die blank from the machine, from where this can possibly be used for other purposes whilst re-programming of the tool path proceeds. Once this re-programming is finished the renewed numerically controlled working then generally requires a new loading and repositioning of a die blank into the machine.

In such cases the re-programming of the numerically

controlled working may take place after a damaging event has occurred, such as damage to the die blank being worked, damage to the machine tool or breakage of the tool etc, and in any event every tool path reprogramming intervention involves stopping the machine tool and this is detrimental to the efficient productivity of the workshop and creates problems from the point of view of achieving smooth activity.

With the above described traditional approach the machine tool operator is relegated to a secondary, passive role, and his specific know how is only employed and marginally.

The object of the present invention is to provide a tool working system which makes it possible to obviate the above-described disadvantages.

This object is achieved according to the invention by means of a working system of the type previously described, the principal characteristic of which lies in the fact that it comprises in combination

a machine tool, in particular a grinding machine, with an associated numerical control system adapted to control its operation on the basis of input information relating to the intended paths to be followed by the tool; and

a CAD work station of interactive graphic type, including memory means adapted to store a predefined mathematical model of the shape to be formed, and an electronic computer unit operable to communicate with the numerical control system of the machine tool according to predefined protocols; the said unit being pre-arranged to determine, on the basis of the said mathematical model and of the nominal geometric characteristics of the blank workpiece, the coordinates of the points which define the paths intended to be followed by the tool of the said machine for working the said blank workpiece, and to transmit to the numerical control system of the machine tool the coordinates of the points of the said paths gradually as they are calculated, for immediate execution by the machine tool; and

control means actuable by an operator, adapted to allow interaction with the said electronic computer unit to modify and/or integrate in real time the paths of the tool calculated by the said unit, on the basis of observation of the work in progress on the blank workpiece.

With the system according to the invention re-programming of the tool paths may become necessary can be made in real time, directly on the machine tool.

The system of the invention therefore makes it possible overall to optimise the use of the numerically controlled

machine tool and moreover makes it possible to make the best use of the knowledge and experience of the employee operating the system.

Further characteristics and advantages of the invention will become apparent from the following detailed description, made with reference to the attached drawing, provided purely by way of non limitative example, in which a real time grinding system formed according to the invention is schematically illustrated.

In the drawing the reference numeral 1 generally indicates a machine tool, in particular a grinding machine, with a bed 2, a workpiece-carrier platform 3 on which is mounted a blank work piece 4, and a movable head 5, movable along three or five axes, which carries the tool 6.

The machine 1 has associated with it a computerised numerical control system indicated 7. By means of a line 8 a CAD work station 9 of interactive graphic type is coupled to this computerised numerical control system. In the exemplary embodiment illustrated the work station 9 comprises a keyboard, a computer 11 with annexed memory devices, and a video display 12.

In the memory devices associated with the computer of the

work station 9 there is stored a predefined mathematical model of the shape of the work piece, model or die to be produced.

With known programming techniques the computer 11 is arranged to determine, on the basis of the mathematical model of the shape to be produced and of the nominal geometrical characteristics of the blank work piece 4, the coordinates of the points which define the paths intended to be followed by the tool 6 of the machine 1 for the purpose of being able to produce the desired shape from the said blank work piece.

The unit 11 is moreover conveniently arranged for two-way communication through the line 8 with the computerised numerical control system 7 of the machine 1, according to predefined protocols. Moreover, the said unit is pre-arranged, by means of suitable software, for transmitting to the numerical control system 7 of the machine 1 the coordinates of the points of the tool paths gradually as these are calculated, for their immediate execution by the machine.

In the above-described system the working, in particular the grinding of the blank work piece 4, therefore takes place in real time.

Conveniently, by means of suitable applications software, the unit 11 of the work station 9 is arranged to allow modification and/or integration in real time, on the basis of direct observation of the work in progress on the blank work piece, the paths of the tool which from time to time are calculated to compensate possible inadequacies of the said paths which must have arisen, for example, by the effect of discrepancies in the effective geometric dimensions of the blank work piece with respect to its real geometric dimensions, or for other reasons.

With the system of the invention, however, when such inadequacies become apparent, it is not necessary to stop the machine tool and reprogramme the paths, but rather such inadequacies can be immediately rectified in real time. This makes it possible to optimise the use of the machine tool and also makes it possible to avoid having to proceed to redefinition of the work plans of the machine and/or of the workshop.

The work station 9 can for example be an SUN work station with Computervision CAD software or with other specific applications software. The machine tool 1 for example be a grinding machine produced by JOBS, and the associated computerised numerical control system 7 may be a Fidia CNC20 system.

Naturally, the principal of the invention remaining the same, the embodiments and details of construction can be widely varied with respect to what has been described and illustrated purely by way of non-limitative example, without by this departing from the ambit of the present invention.

CLAIMS

1. A tool working system, in particular a grinding system, for the production of a workpiece such as a die for a motor vehicle body part, starting from a blank workpiece (4) of predefined nominal shape and dimensions, the system being characterised by the fact that it comprises, in combination

a machine tool (1), in particular a grinding machine, with an associated computerised numerical control system (7) adapted to control the operation of the machine tool (1) on the basis of input information relating to the intended paths to be followed by the tool (6); and

a CAD work station (9) of interactive graphic type, including memory means (11) adapted to store a predefined mathematical model of the shape to be produced, and an electronic processing unit (11) adapted for two-way communication with the numerical control system (7) of the machine tool (1) according to predefined protocols; the said unit (11) being pre-arranged to determine, on the basis of the said mathematical model and of the nominal geometric characteristics of the blank workpiece (4), coordinates of the points which define the paths intended to be followed by the tool (6) of the said machine (1) for working the blank workpiece (4), and for transmitting to the numerical control system (7) of the

machine (1) the coordinates of the points of the said paths, gradually as they are calculated, for their immediate execution by the machine (1); and

control means (10) actuable by an operator and adapted to allow interaction with the said unit (11) to modify and/or integrate in real time, on the basis of observation of the work in progress on the blank workpiece (4), the paths of the tool (6) calculated by the said unit (11).

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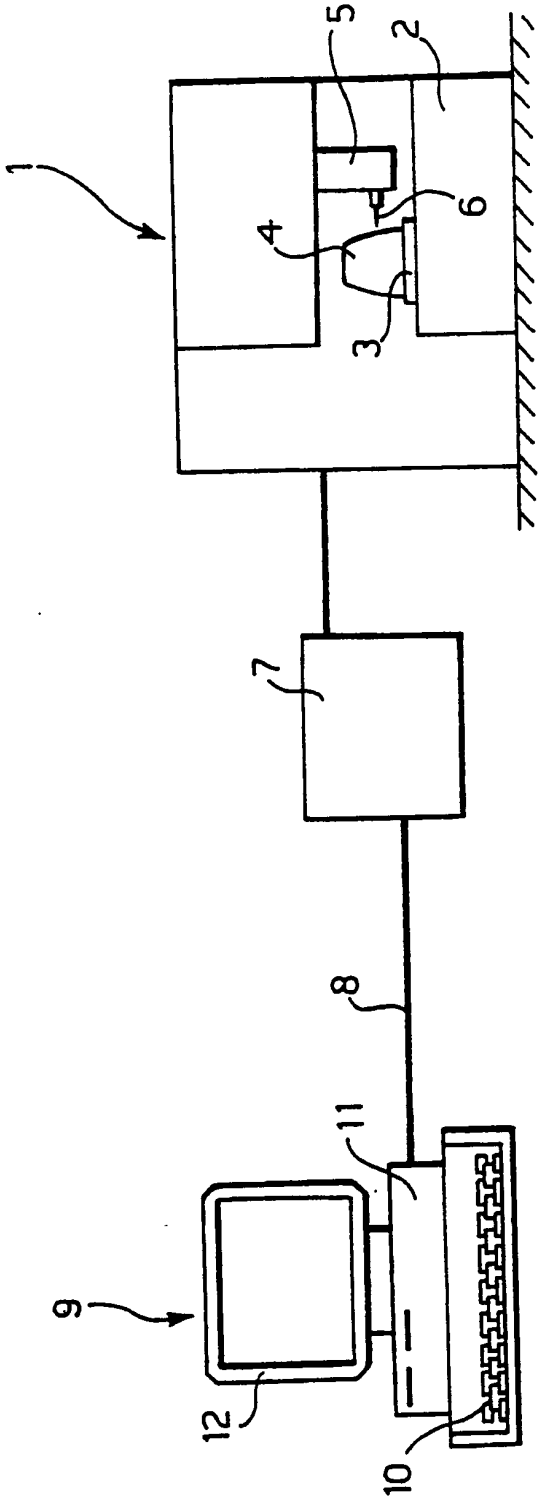

FIG. 1

INTERNATIONAL SEARCH REPORT

International Application No PCT/EP 92/02468

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 G05B19/405

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	G05B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
Y	TECHNISCHE RUNDSCHAU. vol. 80, no. 47, 18 November 1988, BERN CH pages 26 - 29 , XP65194 STEPHAN ACÉL, WOLFGANG HUBER 'Von der Konstruction direct zur NC-Maschine' see page 27, right column, paragraph 1 see page 29, right column, paragraph 1 ---	1
Y	MACHINE DESIGN vol. 62, no. 15, 26 July 1990, CLEVELAND US pages 50 - 61 , XP148354 JOHN KROUSE, PAUL DVORAK 'Successfully applying CAD/CAM' see page 58, left column, paragraph 4 - middle column, paragraph 1; figure PAGE --- -/--	1

° Special categories of cited documents : [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
18 FEBRUARY 1993	26.02.93
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	RESSENAAR J.P.

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	WERKSTATT UND BETRIEB. vol. 122, no. 6, June 1989, MUNCHEN DE pages 93 - 98 , XP46763 A. HOFMANN 'CAD/CAM-Einsatz bei einem Werkzeug-, Form- und Modellbauer für die Automobilindustrie' see page 94, right column, paragraph 4 - page 96, left column, paragraph 5	1
A	ZWF ZEITSCHRIFT FUR WIRTSCHAFTLICHE FERTIGUNG vol. 84, no. 1, January 1989, MUNCHEN DE pages 38 - 42 , XP8699 DR.-ING. W. WALTER 'CAD-NC-Kopplung mit CAD-Funktionalität' see page 39, left column, paragraph 3 - page 40, right column, paragraph 4	1